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A comparative study of stylus maze learning by blind and seeing children.

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A COMPARATIVE STUDY OF STYLUS MAZE LEARNING BY BLIND AND SEEING SUBJECTS

BY HELEN L. KOCH AND JENNETTE UFKESS

University of Texas

The purpose of the study was to check with more adequate controls with respect to age, intelligence, and number of subjects some incidental observations made a few years ago by one of the authors upon the maze-learning of the blind. These observations, which are quoted by Dr. H. A. Carr in "The influence of visual guidance in maze learning,"[1] indicate that the usual maze presents to the blind more difficulties than to those with normal vision. This result is distinctly contrary to *a priori* judgment, for a stylus-maze was employed which all of the subjects mastered without the aid of vision; and we are likely to argue in this case that the blind, who make so many of their spatial adjustments on a tactual-kinæsthetic-motor plane, will find little that is novel or difficult in the maze problem; whereas the normal subjects, deprived of the visual cues upon which they are wont heavily to depend, will be considerably disturbed. We tend to overlook, however, the possibility that the mere fact of visual experience may provide a more adequate system of spatial symbols than does the sensorially more restricted experience of the blind. These action-patterns developed through vision may function, in other words, to overbalance any handicap to the normal subject in the maze resulting from his usual modes of reacting.

The blind subjects, 19 in number, who served in the present investigation constituted the adolescent group in the Texas School for the Blind at Austin. The ages, as indicated in Table III., range from 14 to 26 years. Some of the subjects have not been totally blind from birth, and some even now possess what is known as 'shadow vision.' A description of the visual capacities of each subject is given in Table I.

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[1] This Journal, 1921, *4*, 399–417.

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same individuals can not read English when horizontally arranged with the same relative facility as can those with less training. Under these conditions of relative strength, the two habits conflict and mutually interfere with each other. This hypothesis is at least suggestive from the standpoint of the study of the mutual relations of two antagonistic habits.

TABLE I

YEARS AND TYPE OF VISUAL EXPERIENCE BEFORE ONSET OF BLINDNESS

Subj.	Description of Visual Experience
1B–6B	All totally blind from birth.
1PB	Detail vision for 6 years, then total blindness.
2PB	Detail vision for 3 years, then total blindness.
3PB	Shadow vision for 14 years, then total blindness.
4PB–8PB	Detail vision for 7, 12, 3, 9, 5 years (resp.), then total blindness.
9PB	Shadow vision for 13 years, then total blindness.
10PB	Detail vision for 8 years, then total blindness.
11PB	Shadow vision, never total blindness.
12PB	Shadows and gross details for 17 years, then total blindness.
13PB	Detail vision for 15 years, then total blindness.

Those individuals who have not always been deprived of their sight are valuable for our analysis, since not only do they furnish us an interesting intermediate to the extreme groups—*i.e.*, those with average vision and those with complete life-long blindness—but they also enable us roughly to gauge the effect of varying degrees of visual experience.

The 20 normal subjects were selected from at least 100 senior-high-school and university students, as those who paralleled most successfully in age and intelligence the blind group. All but 5 of the 20 are high-school students. The age range of the normal subjects is from 14 to 32 years.

An approximate pairing of the two groups on the basis of age and intelligence was deemed advisable, first, because of results like those of Hunter[2] and of Warden,[3] which indicate a correlation of moderate degree between skill in the mastering of mazes and performance in the intelligence-test; and, secondly, because the blind group, taken *en masse*, may perhaps be suffering some intellectual handicap as a result of the general physical and nervous disabilities produced by the same factors which mediated their visual defects. Table II. suggests that the caution was justified for, in the case of both blind and normal subjects, homogeneous and small though the groups were, a consistent, medium-sized, negative correlation[4]

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[2] Hunter, W. S., Correlation studies with the maze in rats and humans, *Comp. Psychol. Monog.*, 1922–23, I, no. 1, pt. ii, 37–56.

[3] Warden, C. J., The relative economy of various modes of attack in the mastery of the stylus maze, This JOURNAL, 1924, 7, 243–276.

[4] The Pearson product-moment method of computing correlation was used throughout this study.

TABLE II

CORRELATIONS OF AGE AND INTELLIGENCE-TEST SCORE WITH EACH OTHER AND WITH MEASURES OF MAZE PERFORMANCE. BLIND AND NORMAL GROUPS

Group and Factor Correlated	Age	Intelligence-Test Score	Trials (Maze)	Errors (Maze)	Time (Maze)
Age (Blind Group)......		+.06±.15	+.12±.15	+.09±.15	−.08±.15
Age (Normal Group)....		−.09±.14	+.53±.10	+.31±.13	+.24±.13
Intelligence-Test Score (Blind Group)........	+.06±.15		−.44±.13	−.39±.13	−.47±.12
Intelligence-Test Score (Normal Group)......	−.09±.14		−.19±.14	−.40±.12	−.39±.12

is shown between intelligence-test scores and the difficulty experienced in mastering the maze, as represented by the trials or time consumed or by the errors accumulated. The correlations tend to be slightly greater in the case of the blind group than they are in the normal, probably because the former is somewhat less homogeneous than the latter. Our results, then, in general bear out the results of Hunter and of Warden.

In our blind group, age and maze success do not seem so closely related as do intelligence and the latter, the subjects being practically adult. The positive correlations of moderate size in the case of the normal group between age and the criteria of skill in maze performance, or rather lack of skill as our data are presented, are, doubtless, the result of the method of selecting these subjects. Most of them were juniors taking chemistry in the summer session of the senior-high-school. Since attendance at summer sessions is usually conditioned either by dullness or failure during the year or by unusual interest, success, ambition, etc., we should expect the younger subjects to be generally better equipped from the point of view of intellect than the older ones. The slight negative correlation between age and intelligence supports this hypothesis.

Since no adequate intelligence tests for the blind adolescents or adults were available, the authors found it necessary to adapt to their needs one of the standard group-tests. They are fully aware that in their adaptation the character of the test has been altered and that probably the claims made for the tool as a measure of intelligence in its original standardized form are no longer entirely applicable. Certainly the speed factor was to a large extent eliminated, since the problems were necessarily presented orally, and the subjects at least had (so to say) a chance at every task. It is well to note, also, that while both blind and normal subjects use their aural mechanisms in their daily lives, still the auditory presentation of the material may have offered an unfair handicap to one of the groups. On this point we have no check.

As arguments, however, for the merit of the instrument used by us to measure intelligence let us say, first, that among the 100 normal subjects examined, the university students (mostly sophomores) outstripped the high-school students (mostly juniors) by an average of 20 points, and, secondly, that the correlation between the scores made on our adaptation of the Army Alpha Test by the high-school students (normal group) who served in the maze experiment and the following criteria of intelligence: (*a*) score on the Miller Mental Ability Test, (*b*) the instructor's rating of intelligence, and (*c*) final grades in chemistry were, respectively, + .88 ± .04, + .80 ± .06, and + .44 ± .11.

The test given included all or parts of the following six sub-tests of the Army Alpha (Form 9): the arithmetic, opposites, analogies, number-completion, information, and best-answers. All of the best-answers, opposites, and analogies tests were employed, as were also 16 of the arithmetic problems, 38 of the information, and 15 of the number-completion. Those tests given in part were not completed because their more difficult sections were so far beyond the capabilities of the blind subjects that a recital of them had the effect of completely discouraging the experimental group and of ruining its morale.

Of the 100 university and high-school students who took the test and from among whom our subjects were selected, no one amassed more than 142 points. For the individuals whose performances are reported in this study 118 is the maximal score.

The test was given rather informally to the blind, but still with adherence to most of the details of procedure usually observed. The problems were generally read aloud twice; and, if the group indicated a desire for a third reading, this also was given. Only when the blind subjects showed by their attitude that they had either completed an attempted solution or were unable to solve the problem was the next task presented. This method of administration makes of the test an achievement rather than a speed test. The test as conducted with the blind subjects furnished the standard of procedure for the normal group in regard to such details as instructions, time allotted for each individual problem, etc.

The blind subjects used the Braille apparatus or the typewriter to record their answers, which in each case consisted of a response no more complex than a word, and usually merely a letter or number. The normal subjects wrote their answers with a pencil. How significant an effect this difference in routine may have had we do not know with certainty, though we question, since speed played so small a part in the performance, whether the variation is of any great moment.

The blind group was handled by one experimenter; the normal, by the other. The authors attempted to prevent the personal equation from being introduced as a prominent factor into the results by carefully working over together the details of the administration of both of the tests.

The maze used was a metal stylus maze designed by Dr. Koch,[5] (see Fig. 1) and the general method of conducting the

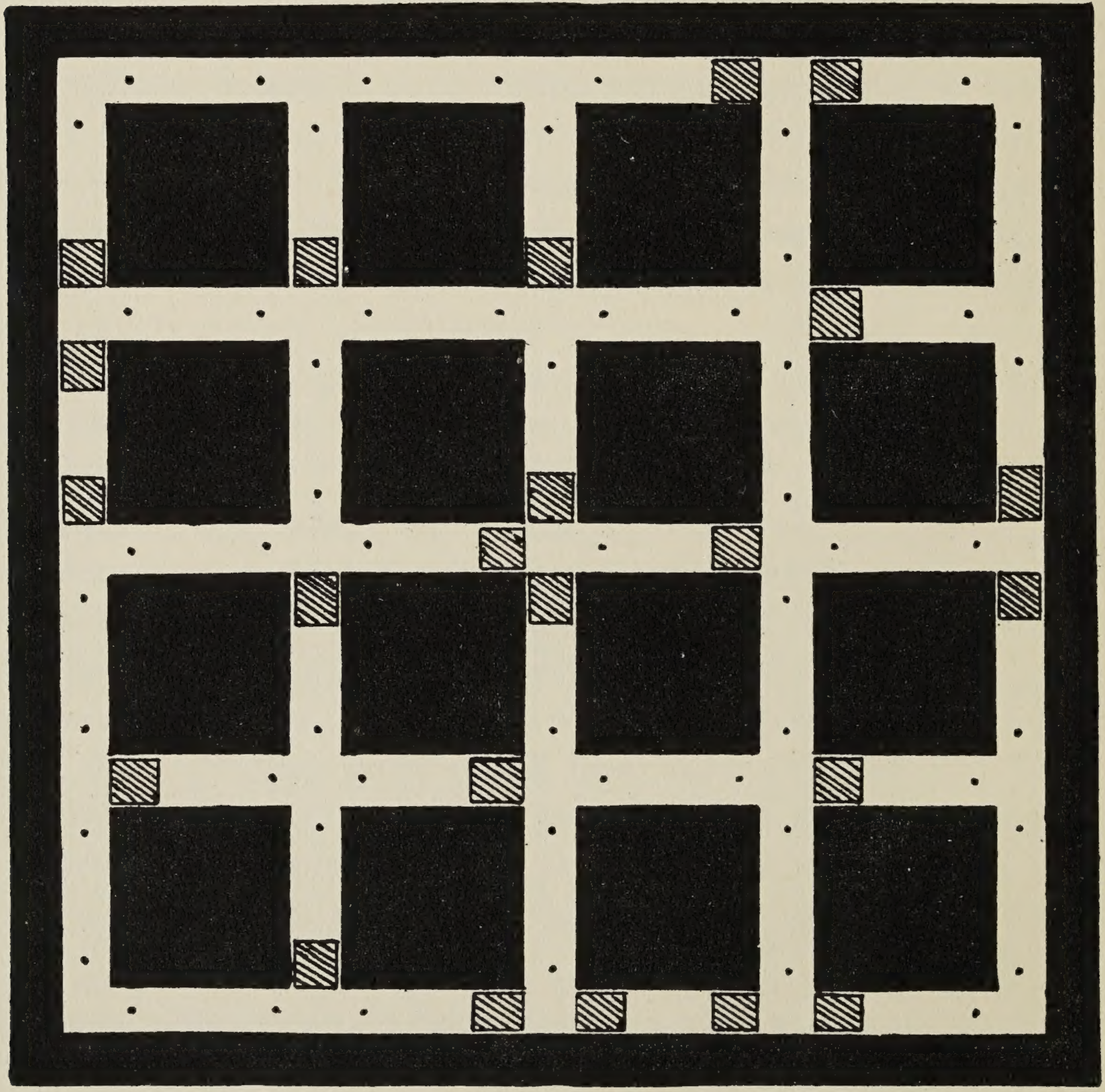

Fig. 1

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[5] This maze has two noteworthy characteristics: (1) the ease with which the distance traversed in it by the learner can be estimated; and (2) the multiplicity of different patterns which it affords. The distance covered can be estimated sufficiently accurately for group comparisons, at least, by merely counting the number of blocks passed by the learner en route to the goal and multiplying this count by the length of one block, as all the alley-ways are divided into segments of equal length.

maze experiment was the same as that described in her monograph, "The influence of mechanical guidance upon maze learning."[6] The canopy which screened the maze from the view of the normal subjects was employed in the case of the blind subjects also, in order to keep the tactual-kinæsthetic situation as nearly identical as possible for the two groups. Time was recorded with a stop watch. A standard of mastery of three successive perfect trials was arbitrarily adopted.

Tables III. and IV. show the maze performance of the blind (as measured by the three criteria, time, trials, and

TABLE III

AGES, INTELLIGENCE-TEST SCORES, AND MEASURES OF MAZE PERFORMANCE. BLIND SUBJECTS

Subj.	Age	Intelligence-Test Score	Trials (Maze)	Errors (Maze)	Time (Sec.) (Maze)
1PB	16	65	9	33	341
2PB	16	72	6	32	493
3PB	16	98	8	85	1267
4PB	21	97	7	59	550
5PB	26	96	9	20	184
6PB	18	115	15	24	120
7PB	20	79	20	32	460
8PB	15	58	9	142	824
9PB	18	58	119	395	3493
10PB	21	90	7	6	144
11PB	18	94	5	78	525
12PB	18	—	5	12	152
13PB	14	99	5	9	146
1B	20	67	27	86	1055
2B	20	72	142	1056	5977
3B	21	98	15	52	359
4B	16	104	20	53	443
5B	16	117	9	25	205
6B	20	—	23	67	728
Median	18.0	94.0	9.0	52.0	460.0
Mean	18.4	87.0	24.2	119.3	919.3
σ Distribution	2.94	18.3	37.21	236.2	1403.4
P.E. Mean	.45	2.83	5.76	36.5	217.1

A very great variety of maze patterns is made possible by the employment of metal pegs at the junctions of the various run-ways. The dots in Fig. 1 indicate the holes in the floor of the maze into any one or group of which the pegs may be inserted. Since the pegs fit snugly and are always set in flush with the walls of the run-ways the subject is unlikely to be disturbed by any roughness or break in a wall which the experimenter desires to be continuous. The positions of the pegs in the maze pattern employed in the study are indicated in the diagram by cross-hatching.

[6] *Psychol. Monog.*, 1923, *32*, no. 147. Pp. vi + 113.

TABLE IV

AGES, INTELLIGENCE-TEST SCORES, AND MEASURES OF MAZE PERFORMANCE. SUBJECTS WITH NORMAL VISION

Subj.	Age	Intelligence-Test Score	Trials (Maze)	Errors (Maze)	Time (Sec.) (Maze)
1N	15	79	10	74	1569
2N	20	75	9	57	525
3N	16	100	4	18	175
4N	14	96	7	10	203
5N	17	104	10	9	189
6N	15	118	8	18	450
7N	17	81	29	52	755
8N	17	56	20	66	1487
9N	16	84	12	47	751
10N	18	89	16	33	429
11N	16	92	12	24	298
12N	16	84	14	22	185
13N	17	92	11	26	391
14N	32	87	57	81	1132
15N	16	92	25	89	662
16N	21	97	3	14	231
17N	28	84	8	16	233
18N	22	93	70	144	1563
19N	16	102	3	7	119
20N	18	102	8	21	317
Median	17.0	92.0	10.5	25.0	410.0
Mean	18.3	90.4	16.8	41.4	583.2
σ Distribution	4.53	12.23	16.98	34.30	470.9
P.E. Mean	.60	1.85	2.56	5.18	70.9

errors) to be inferior to that of the normal subjects, the two groups differing most in respect to their error scores. This relation was likewise observed in our earlier work. None of the group-differences, to be sure, are statistically significant, if a ratio of 3 or more between the difference of the means and the probable error of this difference is accepted as an index of reliability. We may question, however, the use of this index with a few cases. The consistency of the results and their close agreement with our earlier observations merit confidence in their representativeness of what would occur were many more subjects employed.

One may press the question further and note too that, while the blind are almost of the same average age as those with normal vision, they have a very slightly lower intelligence average. The medians, on the other hand, show a reversal of these conditions. A later and more analytical presentation of the data (see Table VII.), moreover, suggests that these small differences in age and intelligence do not destroy the validity of the tendencies shown by the criteria of skill in maze learning.

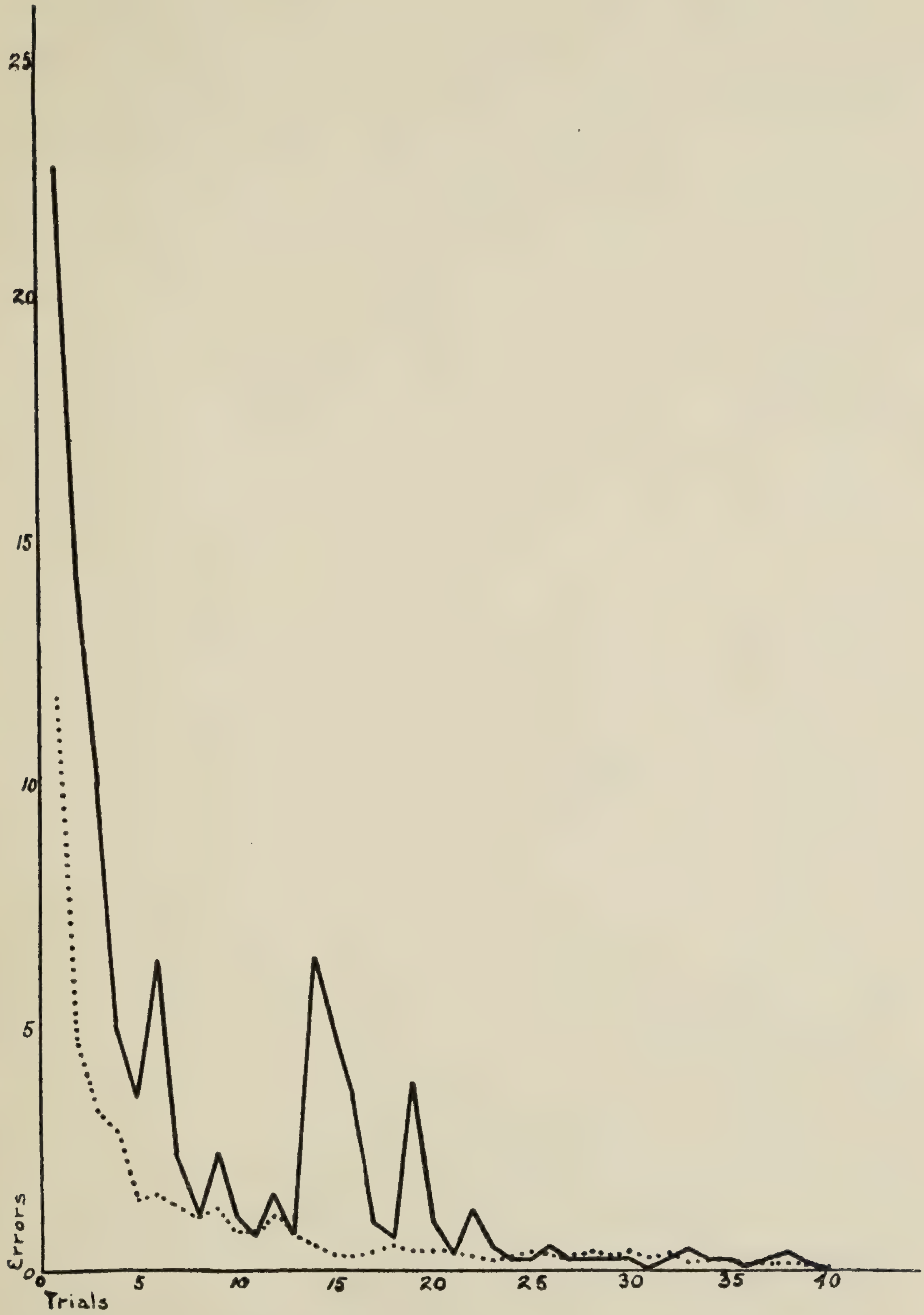

FIG. 2. Curves showing the average number of errors made in the maze problem by the normal and blind groups in each of the first forty trials. The straight-line curve is that of the blind group; the dotted, that of the normal group.

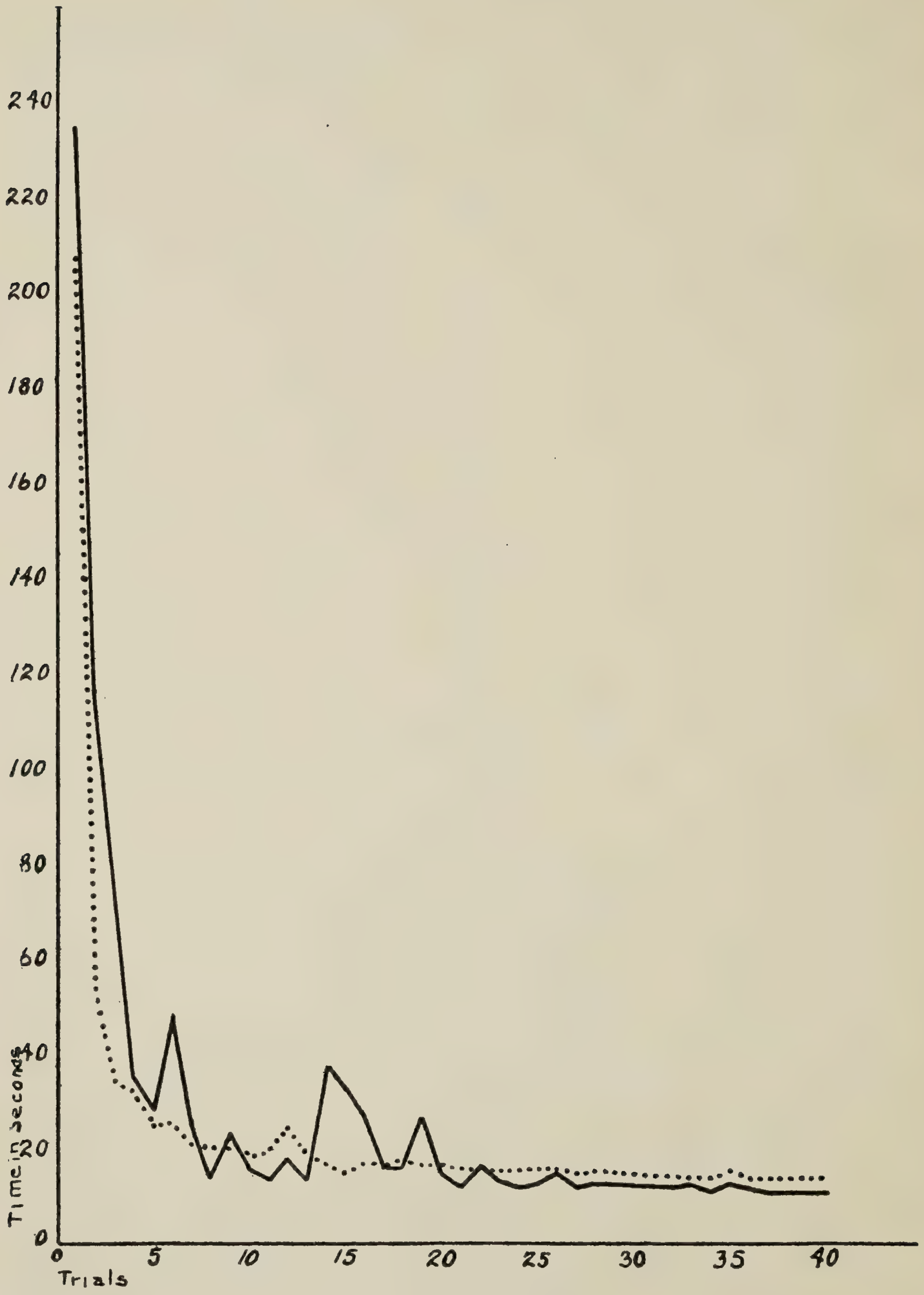

FIG. 3. Curves showing the average number of seconds spent on the maze problem by the normal and blind groups in each of the first forty trials. The straight-line curve is that of the blind group; the dotted, that of the normal group.

The error and time curves (see Figs. 2 and 3) show the learning of the normal group to proceed both more readily and more regularly than that of the blind group. (The curves of the blind group have many more steeples.) The progress of the blind from trial to trial, furthermore, is not only less consistent than that of the normal but the measures of variability (see Tables III. and IV.) indicate that the blind as a group of individuals are also more variable than are the normal subjects.

A separate consideration of the performances of those who have been blind from birth and of those who have had some sight reveals the degree of maze success to be paralleled negatively by the amount of visual deprivation of the subject. (See Table V.) In accordance with this tendency are also the negative correlations between the years of visual experience of the blind and the measures of the difficulty experienced in learning the maze. (See Table VI.) These correlations, to be sure, are small and, hence, their significance is questionable. Still, since the type of visual experience varied—some subjects had many years of shadow vision, while others had a

TABLE V

AVERAGE AGE, INTELLIGENCE-TEST SCORE, AND MEASURES OF MAZE PERFORMANCE. NORMAL SUBJECTS, SUBJECTS TOTALLY BLIND FROM BIRTH AND SUBJECTS BLIND OR PARTIALLY BLIND, BUT NOT FROM BIRTH

Group	Age	Intelligence-Test Score	Trials (Maze)	Errors (Maze)	Time (Sec.) (Maze)
Blind from birth	18.8	91.6	37.7	232.2	1461.2
Blind, but not from birth	18.2	85.1	17.2	71.3	670.0
Normal vision	18.3	90.4	16.8	41.4	583.2

TABLE VI

CORRELATION OF YEARS OF VISUAL EXPERIENCE WITH AGE, INTELLIGENCE-TEST SCORE, AND MEASURES OF MAZE PERFORMANCE. BLIND GROUP

	Age	Intelligence-Test Score	Trials (Maze)	Errors (Maze)	Time (Maze)
Years of Visual Experience	−.06±.15	+.02±.15	−.15±.15	−.19±.15	−.13±.15

TABLE VII

AGE, INTELLIGENCE-TEST SCORE, AND MEASURES OF MAZE PERFORMANCE. FIVE SUBJECTS FROM EACH OF THREE VISUAL GROUPS MATCHED APPROXIMATELY ON THE BASIS OF AGE AND INTELLIGENCE-TEST SCORE

Normal Vision						Blind, but not from Birth						Blind from Birth					
Subject	Age	Intell'ce-Test Score	Trials (Maze)	Errors (Maze)	Time (Sec.) (Maze)	Subject	Age	Intell'ce-Test Score	Trials (Maze)	Errors (Maze)	Time (Sec.) (Maze)	Subject	Age	Intell'ce-Test Score	Trials (Maze)	Errors (Maze)	Time (Sec.) (Maze)
8N	17	56	20	66	1487	1PB	16	65	9	33	341	1B	20	67	27	86	1055
2N	20	75	9	57	525	7PB	20	79	20	32	460	2B	20	72	142	1056	5977
16N	21	97	3	14	231	4PB	21	97	7	59	550	3B	21	98	15	52	359
5N	17	104	10	9	189	3PB	16	98	8	85	1267	4B	16	104	20	53	443
6N	15	118	8	18	450	6PB	18	115	15	24	120	5B	16	117	9	25	205
Mean	18.0	90.0	10.0	32.8	576.4		18.2	90.8	11.8	46.6	547.6		18.6	91.3	42.6	254.4	1607.8

few years of excellent vision—and the mere measure 'years of experience' does not take these differences into account, one would anticipate small correlations.

If we attempt, as a further check, to control in an absolute way, in so far as it is possible to do this with a few cases, the factors of age and intelligence by selecting for comparison from the three visual groups only those subjects highly similar in these respects (see Table VII.), we observe that the same negative relation obtains between the ease with which the maze is mastered and the degree of visual deficiency. A limited amount of vision, however, seems to be fairly effective in reducing the handicap of the blind; for those who have seen at some time in their lives maintain a standard more nearly similar to that of the normal subjects than they do to that of the totally blind. These results, again, support our earlier observations, though the magnitude of the differences between normal and blind subjects is not so great as was indicated in the later findings. We must insist, furthermore, that our comments on the abilities of the blind subjects apply merely to the average. Some of those whose optic apparatus has never functioned attained a much higher degree of success with the maze than did many of those with normal visual powers.

An interpretation of our results in the light of Warden's data seems possible. Warden demonstrated that of the three principal ways of guiding one's conduct in the maze—namely, by giving oneself verbal directions, by building up a visual schema, or by relying upon kinæsthetic and tactual cues—the first is the most effective; the last the least. Those whose visual deprivations have been of life-long duration would necessarily fail to employ the second method, and those whose affliction has been of shorter duration probably would not use the visual schema so much, at least, as would the normal subjects. The blind, then, would rely largely, no doubt, on the first and last techniques suggested; but, since the tactual-kinæsthetic-motor adjustments, which are necessarily the principal bases of the spatial reactions of the blind, are probably not so easily discriminated, (or, as the *Gestalt* psychologist would have it, do not develop so clear a configuration), and hence are not so readily named, as they are when a visual factor is added, we should expect the totally blind, at least, to learn the maze with relatively little verbalizing. Logically, then, the amount of verbalization of a directive sort engaged in should parallel, on the average, the amount of visual experience of the subjects. An entirely satisfactory check on this hypothesis we were unable to obtain because of the general immaturity of our subjects and their unfamiliarity with the technique of self-observation. Notations, however, were made on the conduct of the subject during the learning period. These, crude as they are, do lend the hypothesis some support, for the three individuals, 11PB, 5PB, and 3PB, who gave themselves audible directions to any extent were all among those whose affliction was of rather late origin or whose sight was never entirely destroyed. Their visual experience has extended, respectively, over 17, 12, and 14 years.

Our results we tested, furthermore, by one of Warden's criteria of directive verbalization: namely, the degree of variation in the difficulty of the cul-de-sacs as measured by the average number of entrances. (See Table VIII.) He contends that the variation is least in the case of those who depend largely on the word control and most in the case of the motor learners, the visualizers occupying an intermediate position. While those of our subjects who have never seen do show to a somewhat more marked degree than do the normals the aforesaid variation, the same condition does not obtain for

Table VIII

Relative Difficulty of the Cul-de-sacs. All Groups. Based upon a "Difficulty" Value = 1.0 Given to that Cul-de-sac Entered (on the Average) by Each Group the Least Number of Times

Group	Cul-de-sacs						
	I.	II.	III.	IV.	V.	VI.	VII.
Normal vision	3.44	1.04	1.62	2.92	1.76	5.00	1.00
Blind from birth	5.90	4.01	4.29	6.05	1.00	4.00	2.72
Blind, but not from birth	3.73	1.88	2.21	3.53	1.92	3.96	1.00
Blind group (total)	3.29	2.21	2.90	3.27	1.00	2.72	1.29

those whose visual deprivations are distinctly post-natal. These results, then, are indecisive. A detailed analysis of the cues which the blind do use is a problem still in need of attention and certainly one of no small size. The significance of the problem for the pedagogics of the visually handicapped needs no comment.

SUMMARY

1. Blind subjects tend to be less successful, on the average, in maze-learning of the stylus variety than are normal subjects. The error criterion of skill in maze performance differentiates the two visual groups more markedly than does either the trial or time criterion.

2. Some visual experience before the onset of blindness seems to reduce materially the handicap which the blind as a group appear to suffer.

3. The intelligence of the subject, whether he is with or without defective vision, determines, in part, the ease with which he masters the maze.

THE VISUAL ESTIMATION OF ANGLES

BY MARJORY BATES PRATT

For many years it has been assumed, though not always without question, that acute angles are overestimated, and that obtuse angles are underestimated. This supposition seems not to have been considered interesting in itself, but valuable only as it was related to the study of certain geometrical optical illusions. The assumption as to the overestimation of acute angles, and to a lesser degree the underestimation of obtuse angles, appears to have sprung directly from the study of such illusions, and to have been made in order to provide an explanation for these more complex phenomena.

Hering[1] says that angles less than 60° are overestimated and those greater than 60° are underestimated, on the ground that the Poggendorff illusion disappears at 60°. Elsewhere 90° has been taken as the dividing line in wrong estimation of angles.

Brentano[2] is the first to explain the Müller-Lyer illusion on the basis of overestimation of acute and underestimation of obtuse angles.

Helmholtz[3] remarks, in attempting to account for the Poggendorff illusion, that acute angles seem larger than they really are when they are observed together with obtuse angles.

Wundt[4] regards the overestimation of the acute angle when compared with the obtuse as involving the same principle as that of filled space. In the case of the acute angle the free movement of the eye is inhibited and the angle seems larger because more work has been required in observing it.

Judd[5] speaks of the 'fact' that acute angles are overestimated and obtuse angles underestimated, although he holds that the length of the lines is the important condition in geometrical optical illusions and he considers the wrong estimation of angles as merely a secondary effect.

Pierce[6] tried adjustments of the Poggendorff illusion by the method of average

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[1] E. Hering, *Beitr. z. Physiol.*, 1861, 65 ff.

[2] F. Brentano, Ueber ein optisches Paradoxon, *Zsch. f. Psychol.*, 1892, *3*, 349 ff.

[3] H. Helmholtz, *Handbuch der physiol. Optik*, 1896, *2*, 708 ff.

[4] W. Wundt, *Grundzüge der physiologischen Psychologie*, 1893, *1*, 142 ff.

[5] C. H. Judd, A study of geometrical illusions, *Psychol. Rev.*, 1899, *6*, 241 ff.

[6] A. H. Pierce, *Studies in auditory and visual space perception*, 1901, 271 ff.

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